escape. This fact came to light in the construction of the tunnel for the London and North-Western Railway through Primrose-hill. The designs of Mr. Robert Stephenson for the general tunnel section to be used on the London and Birmingham line gave a partially elliptical section, with an invert forming an arc of a circle. The first tunnel commenced was through the solid chalk, with flints, in the neighbourhood of Watford. The late Sir Charles Fox, then sub-assistant on this division, proposed the substitution of footings to the side wall for the invert shown on the contract drawings in this tunnel. Mr. Stephenson gave his assent, and the gain in economy, and still more in the facility with which the work could be pushed on, were so great that a similar change of section was ordered for the Primrose-hill tunnel. After some little time, however, it became evident that what miners term "creep" was going on. The solid clay, under the pressure of the undisturbed mass above it, began to rise, and, if no remedial measures had been taken, would soon have filled the tunnel to the roof. The original section was therefore reverted to in this place, and the invert inserted, which effectually preserved the tunnel.

This piece of definite engineering experience has the most important bearing on any plan for adding to the width of London Bridge. We have seen the care with which Sir John Rennie provided for the foundations of his piers. That these foundations might be able to sustain a somewhat greater weight is possible; although, as we shall show, it is not certain. But no addition to the width of the bridge is worth considering that does not add accommodation for two additional lines of carriage-traffic to the four now carried by the structure,—that is to say, it is proposed to make Rennie's foundations do, say, 40 per cent. more duty than they were designed to perform. It may be said that by the substitution of iron for stone the additional weight imposed on the foundations will not be proportionate to the additional width given to the structure. But it must be remembered that it is not only dead, but living, weight that will be added by an increase of carriage-way. The vibration is very likely to increase in a greater ratio than the actual weight. Thus the stress thrown on the foundations cannot safely be taken as less than we have indicated.

The account above given of the mode of erecting the bridge, and of the nature of the channel of the Thames at its site, puts out of the question any idea of enlarging the foundations of the piers. To do this, new cofferdams must be driven, and the contraction of the waterway thus occasioned would soon dig below the bottom of the piles on which the structure rests. The alternative would be to carry up additional masonry from the footings of the present piers. How much width could be thus obtained is not evident from the account we have cited; but whether this plan, which would be architecturally the only admissible one, or that of cantilevers, or that of skew-backs, were adopted, we still come to the doubtful expedient of throwing 40 per cent. additional stress on Sir John Rennie's foundations. Will they bear so much more than they were designed to support?

Let us consult the experience of the engineer of the bridge:—"After the fifth arch, the first on the Surrey[*] side, was keyed," says Sir John Rennie, "the sinking was observed to be 4 in., or about 1 in. more than the others. . . . I also observed that two of the quoins on the south-east end of the fourth arch from the Surrey shore had splintered off at the soffit. . . . Upon levelling the piers, it was found that the east end had subsided from 10 in. to 14 in. more than the upper or west end. This I could account for in no other way but that there had been a greater scour here than at the upper end, and that the piles had to some extent been laid bare."

The experience above detailed as to the behaviour of the London clay supplies a link that is wanting in the explanation of this subsidence. The scour of the ebb tide was more powerful than that of the flow; the holes dug below the bridge must thus have been deeper than those above. When the full weight came on the London abutment, it is clear that the clay beneath the foundation yielded. To the depth of from 10 in. to 14 in. it must have been squeezed out towards the least resisting line; that is to say, towards the sea. With this degree of movement the abutment came to its bearing. No subsequent movement was detected by Sir John Rennie, who constantly levelled the arches and piers, for several months after that subsidence, from a fixed standard gauge. But what would have been the result had 40 per cent., or even 15 per cent., more stress been thrown on a foundation which had begun to creep? What will be the result if it is now attempted? We do not imagine that any engineer of position will take the responsibility of the experiment.

We have been induced thus far to dwell on the light which is thrown, by the pen of Sir John Rennie himself, on the delicate equilibrium of the foundations of London Bridge, from the sense of the great danger to which the City authorities, as at present resolved, are about to subject that great national monument. Mr. Colleton Rennie, the editor of the present volume, has published a letter on the subject, in which he very clearly points out the inadequacy of any attempt to facilitate the City and borough traffic by the widening of London Bridge. As to that, there is no room for difference of opinion; that is to say, of educated and intelligent opinion. But Mr. Rennie, with a family pride which is not only pardonable but becoming, dwells on the improbability that any public works constructed by his family should not be able to bear a little judicious alteration. We think, however, that the record, written by Sir John Rennie, is enough to prove that the word judicious cannot apply to any attempt to tamper with a structure satisfactorily erected under such stress of difficulties, which so nearly overcame the equilibrium of the bridge.

Sir John Rennie's first professional occupation was to make the working drawings of his father's designs for Southwark Bridge, in 1814–15. He was then between twenty and twenty-one years of age, his education, in languages, in mathematics, and in the mechanical duties of his profession, having been pursued, up to that time, with a care not very usual amongst the engineers of this country, but which afterwards bore ample fruit. He leaped into the saddle at a bound, for his first independent advice seems to have been that the abutment springers for the iron arches of this bridge should consist of solid blocks of granite, of a size not theretofore introduced in England. To carry out this wise suggestion he paid a visit to Aberdeen. He found the granite quarries in that vicinity to be open only on a small scale for obtaining pitching stones. The proprietors would not bestir themselves to produce larger blocks. Young Rennie explored the country, and found promise of solid and accessible stone at Peterhead, thirty miles from Aberdeen. He describes, in very instructive detail, the procedure by which he quarried, transported, and finally shipped a block of this now well-known red granite, of the unprecedented weight of twenty-five tons. A peep at the hearty hospitality of Mr. Fergusson, of Pitfour, reminds the reader that "'tis sixty years since."

We hope to conclude this notice of a very agreeable book in our next number.

## THE LATE MR. EDWARD ROBERTS, F.S.A.

Mr. Edward Roberts, whose death at the comparatively early age of fifty-six we have already mentioned, has not lately designed many buildings, his practice having mainly consisted of heavy compensation cases in connexion with metropolitan improvements and railway works, in which branch he showed his ability to grasp the general merits of a case as well as the more minute details. Some of his papers which we have seen prove the singular care with which he dealt with his valuations. This attention to the minutiæ of his business contributed to his reputation, and also secured for him the name which he acquired amongst his professional brethren of "Maximum Roberts," on account of the sums which he usually succeeded in obtaining for his clients.

His earliest architectural work of which we know anything is the Institution and Market at New Swindon, a view and plan of which will be found in our volume for 1854.[*] He was architect of Christ's College, Finchley, where he also built a lodge for Mr. Heal. Mr. Roberts was an enthusiastic Freemason, member of the Grand Lodge for many years, also of the Middlesex and Methuen Lodges, and secretary of the former for thirty years. The Methuen Lodge was consecrated at Swindon, we remember, when Lord Methuen laid the first stone of the Institution already referred to.

Mr. Roberts was a Fellow of the Royal Institute of Architects (elected 1860), and a Fellow of the Society of Antiquaries. He was intimately concerned, in connexion with Mr. G. R. Wright, in the foundation of the Junior Athenæum Club, and converting for its purposes a house in King-street, St. James's. When the club removed to Hope House, in Piccadilly, he designed, amongst other works there, the very handsome and commodious Smoking-room which the club possesses.

The subject of our notice had been elected an Associate of the British Archæological Association in 1856, and became one of the Hon. Secretaries in 1862. From that time he attended the Congresses very regularly, and contributed greatly to their success by his lucid description of ancient buildings visited on those occasions, the salient points of which he laid hold of with much facility, and pointed out with equal felicity. The Journal of the Association contains many papers contributed by him, some illustrated by his measured drawings. He took part in the last Congress, that of Evesham, though it was obvious to his friends that his health was in a serious condition. Soon after that event the news reached him of the premature death of his son in a distant country, and the shock appears to have expedited his death. His remains were buried at Kensal-green Cemetery, on Wednesday, the 20th inst., when besides the members of his family, there came a number of his professional brethren, including Mr. T. Blashill, Mr. Loftus Brock, Mr. Warburton Stent, and others, to pay their last affectionate respects to a departed friend.

Mr. Roberts leaves a widow and three daughters to mourn a very great loss.

## WORKS COMPLETED OR IN PROGRESS AT OXFORD.

According to its usual custom at the commencement of Michaelmas Term, the *Oxford Journal* gives a detailed account of the building operations of Oxford during the past twelve months. We cull a few particulars of the more important items of the account, which occupies nearly a page of the *Journal*.

At *Christ Church College* a great deal of work is being done by Messrs. Symm & Co., builders, of Oxford, in the way of alteration if not in the way of improvement. In "Tom Quad" all the decayed stonework is being taken away and replaced with new material, and in place of the parapet erected by Sir Christopher Wren, a new one, consisting of battlements in accordance, it is said, with the original idea, is being erected. Shields bearing the armorial bearings of Henry VIII. and Cardinal Wolsey, the founders, and the benefactors of the college, are being placed at intervals, and it is intended to carry out the alteration entirely round the Quad. Over Kilcanon arch, in the north-east corner, a low tower is being erected with a stair turret, for the purpose of giving greater accommodation. Wall-ribs are being inserted upon the original lines shown round the Quad, and upon the old foundations which were discovered some time since the bases of buttresses are being constructed, the intention being at some future time, it is stated, to erect cloisters. The drive round the Quad has been altered to the original lines, as laid down in an old print bearing date 1673, which will have the effect of making it look much larger, besides providing a more direct approach to the various entrance doorways. A new parapet is also being placed upon the hall, with a pinnacle running up from each buttress to show the different bays, and each alternate panel will contain an elaborately-carved design of the arms of Henry VIII. and Cardinal Wolsey. The whole of the work is being erected in Taynton stone, but has been delayed by the strike among the masons in the summer. The architects are Messrs. Bodley & Garner, London, and the clerk of the works is Mr. Fitzwilliam.

In the *Cathedral* two stained-glass windows have been put in—one by Messrs. Clayton & Bell, and the other by Messrs. Morris & Co. A memorial window is shortly to be placed in the north transept, facing the pulpit, by Messrs. Clayton & Bell. The old heating apparatus at the back of the cathedral has been pulled down, and enables a better view to be obtained of that side from the Broad Walk. The doorway into the Dean's house has been removed into the next bay to where it originally stood.

The "Tea Chest" in which the cathedral bells were placed a few years since, over the staircase leading to the hall, still remains, but plans have been prepared for the erection of a tower, a

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[*] We cite textually, but think Middlesex side is meant.

[*] Vol. xii., pp. 346, 347. See also "A Visit to Swindon New Town," p. 289, in the same volume.